

CERES Terra Edition1A SSF Surface Fluxes - Accuracy and Validation

One of the principal objectives for the CERES data products is to provide improved estimates of surface fluxes (net and downward) for shortwave (SW) and longwave (LW) radiation. To achieve this objective, considerable effort has been focused upon obtaining consistent fluxes at the surface, within the atmosphere, and at the top of the atmosphere, all of which are produced as part of the CERES CRS data product using the SSF as input data. Validated CRS surface fluxes, however, will not be available for some time. A second effort, therefore, uses much simpler algorithms either:

- to directly tie surface fluxes to broadband CERES TOA fluxes such as in Li et al. (1993) and Darnell et al. (1992) for SW fluxes, and Inamdar and Ramanathan (1997) for clear-sky LW surface fluxes.
- or to use simple radiative parameterizations (Gupta 1989 and Gupta, Darnell, and Wilber 1992) to estimate surface fluxes, especially for the case of surface downward LW fluxes which are effectively decoupled from the TOA fluxes for cloudy sky conditions.

These simpler SSF surface flux parameterizations are, therefore, more comparable to results used in past analyses of surface radiation data sets based on ERBE or geostationary data. In general, however, they are not expected to be as precise as the CERES CRS surface fluxes, though they do represent an independent method to get to the more difficult surface flux estimates.

The CERES SSF data product provides 4 surface flux algorithm results:

1. Shortwave Flux Model A, Daytime only, Clear-sky only
 - Net surface fluxes use Li et al. (1993).
 - Downward surface fluxes use Li et al. (1993) for net and Li and Garand (1994) for surface albedo.
2. Shortwave Flux Model B, Daytime only, Clear and All-sky
 - Net and downward surface fluxes use the Langley Parameterized Shortwave Algorithm (LPSA) (Darnell et al. 1992; Gupta et al. 1999).
3. Longwave Flux Model A, Daytime and Nighttime, Clear-sky only
 - Net and downward surface fluxes uses Inamdar and Ramanathan (1997).
4. Longwave Flux Model B, Daytime and Nighttime, Clear and All-sky
 - Net and downward surface fluxes use the Langley Parameterized Longwave Algorithm (LPLA) (Gupta 1989 and Gupta, Darnell, and Wilber 1992).

For Terra surface fluxes, clear-sky conditions are defined for CERES footprints with an imager determined cloud cover percentage less than 0.1%. Thus, to be consistent with the angular distribution models, our validation effort has also taken clear-sky to be defined as a CERES footprint with an imager determined cloud cover percentage less than 0.1%. The SSF surface fluxes are being validated using both theoretical analyses and simultaneous matching of satellite data to a range of surface sites. Preliminary results are discussed in the sections which follow.

The CERES SSF surface flux estimates will initially be obtained by using the Terra satellite data from November 2000 through August 2002. The coincident surface fluxes will nominally be gathered from the 21 sites of the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) network, 6 sites of the Climate Modeling and Diagnostic Laboratory (CMDL) network, and 4 sites of the Baseline Surface Radiation Network (BSRN). Unless otherwise noted, surface site fluxes are 1 minute averages and are compared to the CERES footprint which includes the surface site.

Currently, validation results for the CERES Terra instruments are unavailable, and thus, the Shortwave and Longwave comparison tables in this document have been left temporarily empty. We anticipate, however, that the [validation results for the CERES TRMM instrument](#) will prove to be representative of the CERES Terra results for tropical and mid-latitude regions, and thus, the TRMM results should provide a reasonable estimate of the accuracy and precision of the Terra results for the low and middle latitudes. In the meantime, validation efforts continue, and preliminary validation of Terra surface fluxes are expected to be made available as early as Summer 2002, with more robust results expected by late-Fall 2002.

In contrast, Terra measurements of polar surface fluxes will not be completely validated until 2 years of the Terra Edition1A SSF have been produced. At that time, we anticipate that Terra Edition2 angular distribution models will have been developed and validated for snow and ice backgrounds. While surface flux values are included for the polar regions in the SSF Edition1A, they may have large errors from the use of

theoretical snow and ice angular distribution models. Thus, data users should be aware that the high latitude and polar surface fluxes from Terra Edition1A have not been completely validated and therefore should be considered "Beta" quality. An analysis of the accuracy of a pre-Edition1A set of the Terra surface fluxes is underway using the ARM polar surface site, and will be added to the data quality summary in September/October of 2002. CERES data users are welcome to help in this validation effort and provide Dave Kratz (david.p.kratz@nasa.gov) any information concerning studies of the data quality of the polar surface fluxes in Edition1A. Once the Terra Edition2 angular distribution models have been made available, we will produce a validated Terra Edition2 SSF data product (currently scheduled to be produced in July, 2003).

Clear-sky Shortwave Downward Flux Validation: Model A and B

For the shortwave, two models have been used to produce the surface fluxes. Both of these shortwave models are part of our validation effort; however, Model A currently produces fluxes only for clear-sky conditions while Model B produces fluxes for both clear and all-sky conditions. When the column ozone exceeds 500 DU, Model B net and downward SW surface flux values are not computed. Instead they are set to the CERES fill value.

[Validation studies of the TRMM Edition 2A surface fluxes](#) demonstrated that shortwave Model A overestimated surface insolation at the ARM Central Facility by approximately 30 W m⁻². Considering that such biases were not observed for pristine high-latitude surface sites, it was hypothesized that the effects of aerosols could be the cause. Thus, an aerosol correction factor based on the Masuda et al. (1995) method and using the GFDL climatological aerosols (Haywood et al., 1999) was incorporated into shortwave Model A. The use of the Masuda et al. (1995) method with the GFDL climatological aerosols was shown earlier to produce a significant improvement to shortwave Model A.

The following table for the clear-sky cases will compare shortwave Models A and B to the surface measured fluxes.

Downward Shortwave Model A Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
Arm Extended Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
BSRN Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
CMDL Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²

Downward Shortwave Model B Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
Arm Extended Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
BSRN Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
CMDL Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²

Results will also be presented for the all-sky Model B case. To reduce the considerable variance introduced by broken cloud fields, the surface data will be averaged over the 60 minutes centered on the time of the satellite overpass. Note, the variance introduced by broken cloud fields is far greater than that introduced by the temporal averaging.

Downward Shortwave Model B Comparisons, All-Sky, 60 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
Arm Extended Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
BSRN Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
CMDL Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²

Clear-sky Longwave Downward Flux Validation: Model A

Longwave Model A uses CERES-derived window and non-window TOA fluxes as well as the meteorological profiles to obtain surface fluxes for clear sky conditions.

Downward Longwave Model A Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
ARM Extended Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
BSRN Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
CMDL Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²

[Theoretical studies](#) and validation studies employing data from Central Equatorial Pacific Experiment (CEPEX), reported by Inamdar and Ramanathan (1997), are consistent with our results. The parameterization over land surfaces was initially developed using a limited set of emissivity data available from IRIS measurements aboard NIMBUS 4 (Prabhakara and Dalu 1976). The current version of longwave Model A, however, was developed using the global emissivity maps developed by Wilber et al. (1999) and thus can be applied to the extra-tropics as well as to the tropics. Other possible sources of errors include:

1. Specification of the true radiating temperature (especially land surfaces);
2. Errors in scene identification;
3. Emissions from aerosols in the boundary layer. For instance, Inamdar and Ramanathan (1997) noted that sensitivity studies had revealed that thick haze in the boundary layer (visibilities less than 15 km) could increase the downward emissions by about 3 - 5 W m⁻².

All-sky Longwave Downward Flux Validation: Model B

Longwave Model B uses the meteorological profiles and CERES VIRS-derived cloud properties, but not the CERES-derived TOA fluxes, to obtain surface fluxes for clear and all-sky conditions.

Downward Longwave Model B Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
Arm Extended Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
BSRN Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
CMDL Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²

Downward Longwave Model B Comparisons, All-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	n	x W m ⁻²	y W m ⁻²	z W m ⁻²
Arm Extended Facilities	n	x W m ⁻²	y W m ⁻²	z W m ⁻²

BSRN Facilities	n	$x \text{ W m}^{-2}$	$y \text{ W m}^{-2}$	$z \text{ W m}^{-2}$
CMDL Facilities	n	$x \text{ W m}^{-2}$	$y \text{ W m}^{-2}$	$z \text{ W m}^{-2}$

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